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CHAPTER FOUR:

AGGREGATE SPECIFICATIONS *and* REQUIREMENTS

Specifications are generally clear, concise, quantitative descriptions of the significant characteristics of a construction material. The specifications required by INDOT are documented in the latest edition of the Standard Specifications and the current Supplemental Specifications. The specifications for aggregates are detailed in Section **904** and other sections for the various types of construction. These specifications are to be followed when inspecting aggregates.

There are two general types of requirements for aggregate: quality and gradation.

PHYSICAL QUALITY REQUIREMENTS

Physical quality requirements are all specification provisions other than those dealing with gradation or usage requirements. These requirements can be divided into five distinct groups as follow:

- 1) Absorption;
- 2) Abrasion resistance;
- 3) Soundness;
- 4) Restriction on deleterious constituents; and
- 5) Special requirements.

FINE AGGREGATES

Section **904.02** defines the acceptable limits for all uses of fine aggregates.

Fine aggregates are not divided into classes. The quality ratings assigned to fine aggregates regarding their approval for use on highway construction projects are:

A5 = approved for all uses;

B5 = approved for all uses where manufactured fine aggregate is allowed; and

G5 = not approved.

The “A” rating is for all natural sands. The “B” rating is for manufactured fine aggregates.

COARSE AGGREGATES

Section **904.03** defines the acceptable limits for all uses of coarse aggregates.

Coarse aggregates are divided into classes based on quality requirements as noted on the Classification of Aggregates table. Class AP is the highest class and is assigned to aggregates which meet the requirements for all INDOT uses. Some INDOT contracts specify type AP aggregates for use in specific applications of portland cement concrete. Parameters concerning type AP aggregate are contained in **ITM 210**. Aggregates having restricted approval are rated Classes B, C, D, E, and F.

PHYSICAL QUALITY TESTS

Approval and use of aggregates is based upon meeting test requirements in the following physical tests.

ABSORPTION

The absorption quality requirement applies only to coarse aggregates, but this data is necessary on fine aggregate for other purposes, such as mix design and water/cementitious ratios.

All aggregates are porous, but some are more porous than others. How porous an aggregate is determines how much liquid can be absorbed when soaked in water. **AASHTO T 85** defines absorption as the increase in the weight of aggregate because of water in the pores of the material, but not including water adhering to the outside surface of the particles. Absorption is expressed as a percentage of the dry weight.

Absorption requirements are of concern only regarding aggregates used in hot mix asphalt and portland cement concrete. The intent is to avoid using highly porous, absorptive aggregates because extra water and cement or asphalt is needed to make a good mix. However, some aggregates, such as blast furnace slag, may be used despite their high absorptive capacity because of other characteristics that make them desirable, including skid resistance, economics, etc.

The maximum percentage of absorption allowed by the Standard Specifications is 5.0 percent and applies to aggregate Classes AP, A, B, and C only.

ABRASION RESISTANCE

Abrasion resistance applies only to coarse aggregates.

Aggregates vary in their resistance to fracturing under impact (toughness) and breaking down into smaller pieces from abrasive action (hardness). The acceptable limits are set by the Los Angeles Abrasion Test **AASHTO T 96**.

The limits vary from 40.0 to 50.0 percent, depending on the classification of the aggregate. The percentage is a measure of the degradation or loss of material as a result of impact and abrasive actions. Section **904.03** details the requirements. Abrasion requirements do not apply to blast furnace slag.

SOUNDNESS

The quality of soundness applies to both fine and coarse aggregates. The durability of aggregates or their resistance to the forces of weathering is undoubtedly one of the most important considerations in the selection of a material for highway construction. The primary exposure that INDOT is concerned with is alternate freezing and thawing.

INDOT uses three different test methods to evaluate soundness:

- 1) The sodium sulfate test in **AASHTO T 104**;
- 2) The brine freezing and thawing test in **ITM 209**; and
- 3) The freezing and thawing test in **AASHTO T 103**.

The sodium sulfate test requires immersing an aggregate sample in a sodium sulfate solution for a period of time and then determining the weight loss of

particles on a given set of sieves. The brine freeze and thaw test requires the aggregate to be enclosed in a bag containing a 3 percent sodium chloride solution and subjected to 25 cycles of freeze and thaw. The water freeze and thaw test requires the aggregate to be sealed and totally immersed in water and subjected to 50 cycles of freeze and thaw.

The freezing and thawing in water test is the method that most accurately simulates actual field conditions, but the test requires a long period of time to conduct. The “quick” checks for soundness of the aggregate are the brine freeze and thaw and sodium sulfate test. If the aggregate fails either the brine freeze and thaw or the sodium sulfate test, the material is tested using the freeze and thaw method with water. An aggregate that reasonably fails the brine freeze and thaw and/or sodium sulfate test but then passes the freeze and thaw in water method is an acceptable material for use on INDOT contracts.

DELETERIOUS MATERIALS

Certain substances in aggregates are undesirable for use in portland cement concrete. Therefore, the Standard Specifications limit the amount of deleterious constituents to a level consistent with the quality sought in the final products.

Organic impurities are the only concern in fine aggregates. Section **904.02** places a restriction for fine aggregate for use in portland cement concrete and mortar. No restrictions are placed on organic impurities in fine aggregate for use in other types of construction.

The limitations on the amount of organic impurities allowed in fine aggregates are determined by the test method for organic impurities in **AASHTO T 21** and the test method for Mortar Strength in **AASHTO T 71**. According to the Standard Specifications, materials failing the organic impurities test are to be tested for the effect of organic impurities using the mortar strength test. The results of the test are the basis for acceptance or rejection of the fine aggregate.

Section **904.03** includes a general statement regarding deleterious substances that applies to all classes of coarse aggregates. Section **904.03** also details more specific restrictions for other harmful substances as a maximum allowable percentage of the mass of each of the deleterious materials in a total sample of aggregates being tested. Figure 4-1 illustrates the materials which are classified as deleterious and the specification limits for each.

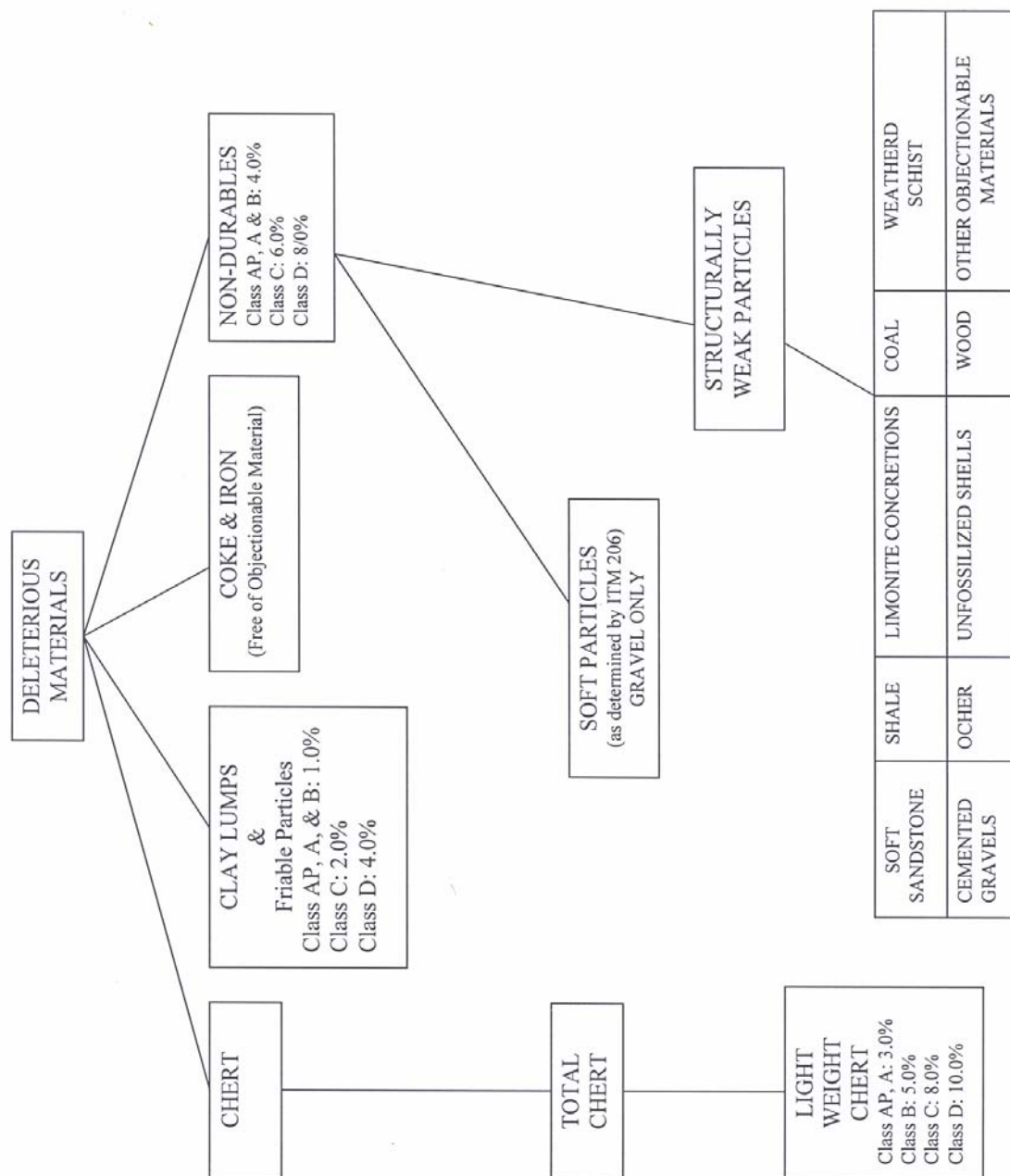


Figure 4-1. Deleterious Materials

Clay Lumps and Friable Particles

Clay lumps and friable particles are materials that are easily crumbled or mashed with the fingers. Testing for these particles is performed by **AASHTO T 112**, Clay Lumps and Friable Particles in Aggregates.

Non-Durables

Non-durable particles are divided into two types: soft materials as determined by **ITM 206**, Scratch Hardness, and structurally weak material as determined by visual inspection. Structurally weak materials include the following:

- 1) Conglomerates -- cemented gravels.
- 2) Soft sandstone.
- 3) Shale -- laminated rock of clay-size minerals.
- 4) Limonite -- iron oxide ranging in color from brown to black and is frequently a concretion around a soft core.
- 5) Weathered schist -- structurally weak.
- 6) Ocher -- soft rock clay to sand particles cemented with iron oxide which ranges in color from tan, through yellows, reds, and browns (looks and acts like chalk).
- 7) Shells -- unfossilized shell of fresh water clams.
- 8) Coal, wood, and other foreign materials.
- 9) Materials with loosely cemented grains and/or a weathered coating.

Coke and Iron

Coke and iron are of concern only with the slag materials. Coke is a by-product from air-cooled blast and steel furnaces. Slag from these furnaces normally are free of objectionable amounts of coke and iron.

Chert

Chert is a rock of almost any color and is composed of glassy silica and very fine-grained quartz. Chert breaks into rounded surfaces with sharp edges. Unweathered chert appears hard, dense and brittle with a waxy or greasy texture. Weathered chert appears chalky or earthy and porous with a dull texture.

SPECIAL REQUIREMENTS

In some cases, aggregates must meet special requirements for a particular use in construction as required by various Sections of **904**. Some contracts may specify a unique gradation or aggregate. Details pertaining to this special requirement will appear in the Special Provision section of the contract proposal booklet for that contract.

Fine Aggregates

Natural sand used for HMA mixtures is required to have an acid insoluble content of not less than 40 percent. For air-cooled blast furnace slag or granulated blast furnace slag sand the acid insoluble content must not be less than 25 percent. The acid insoluble content is determined by **ITM 202**.

All fine aggregates used for HMA are required to be in accordance with **904.02** for soundness. If soundness testing cannot be conducted, the aggregate shall originate from a Category I source in accordance with **ITM 203**.

All Coarse Aggregates

A special requirement placed on all coarse aggregates concerns the restriction on the number of flat and elongated pieces. Section **904.03** sets the limits for the number of flat and elongated pieces. A flat and elongated piece is defined as one having a ratio of length to thickness greater than five. The method for determining the actual percentage of elongated pieces is described in **ASTM D 4791**.

Dolomitic Aggregates

There is a special requirement to be met when dolomitic coarse aggregates are specified in HMA. These aggregates are specified for use under some conditions to obtain high-friction, skid-resistant HMA surface courses.

ITM 205 is used to ensure that the aggregate proposed is carbonate rock containing at least 10.3 percent elemental magnesium.

Polish Resistant Aggregates

Aggregates that meet the requirements of **ITM 214** may be used in place of dolomitic aggregates in HMA surface mixtures. The procedure for approval requires initial British Pendulum testing, placement of a test section on an INDOT project, and subsequent skid testing for two years.

Sandstone Aggregates

Coarse sandstone must meet the Class B quality requirements, and may only be used in HMA surface mixtures. Sandstone is defined as a sedimentary rock composed of siliceous sandgrains containing quartz, chert, and quartzose rock fragments in a carbonite matrix or cemented with silica, calcite, or dolomite.

Slag Aggregates

When slag is furnished as an alternate to natural aggregate and payment is on a weight basis, adjustments must be made to compensate for the difference in specific gravity of the slag compared to the specific gravity of the natural aggregate. For any pay item less than 500 tons on a contract, no adjustment is made. The following typical values should be used.

TYPICAL VALUES FOR SPECIFIC GRAVITY	
Natural aggregates (both fine and coarse)	2.6
Air cooled blast furnace slag coarse aggregate	2.3
Air cooled blast furnace slag fine aggregate	2.6
Granulated blast furnace slag fine aggregate	2.1
Steel furnace slag, both fine and coarse	3.2

Gravel Coarse Aggregates

There is a specific requirement for gravel coarse aggregates regarding crushed particles. This requirement applies, however, only when gravel coarse aggregates are used in HMA, compacted aggregates, and asphalt seal coats except asphalt seal coats used on shoulders. Crushed particles are defined as those particles having one or more sharp, angular, fractured faces. Fractured faces that have an area less than 25 percent of the maximum cross sectional area of the particle are not considered crushed. **ASTM D 5821** is used to determine the crushed particle content. Crushed gravel must comply with the requirements in **Section 904.03**.

Type AP Aggregate

INDOT requires specific applications of portland cement concrete to be constructed with AP aggregate. Details and parameters concerning AP aggregate are described in **ITM 210**.

Blended Aggregates

The total blended aggregate from the fine and coarse aggregates, and recycled materials used in HMA shall meet the fine aggregate angularity (FAA) requirements of **Section 904.02(b)**. The procedure for determining the FAA value is described in Method A of **AASHTO T 304**.

The clay content of the blended aggregate shall meet the requirements of **Section 904.02(b)**. The procedure for determining this value is described in **AASHTO T 176**.

GENERAL USAGE REQUIREMENTS

The general usage requirements first describes the type of material which is considered acceptable for the type of construction, and, second, describes the requirements which influence the acceptability of the material.

FINE AGGREGATES

Section 904.02 states that fine aggregate shall consist of natural sand or manufactured sand produced by crushing limestone, dolomite, steel furnace slag, air cooled blast furnace slag, granulated blast furnace slag, or wet bottom boiler slag. At the time of use, these materials shall be free from lumps or crusts of hardened or frozen materials. The detection of lumps or crusts of hardened or frozen materials is possible only through visual inspection.

THE SPECIFIC REQUIREMENTS OF FINE AGGREGATES
IN ACCORDANCE WITH SECTION 904.02:

TYPE OF CONSTRUCTION	ACCEPTABLE FINE AGGREGATE
Portland cement concrete for pavement or bridge decks	Natural sand
Portland cement concrete for other construction	Natural sand or crushed limestone, dolomite, or air-cooled blast furnace slag.
Hot mix asphalt	<p>Natural sand or manufactured sand.</p> <p>Steel Furnace slag sand is permitted only with Steel Furnace coarse aggregate.</p> <p>Combination of natural sand and manufactured sand is permitted. However, not more than 20 percent of the total aggregate used in hot mix asphalt surface mixtures with ESAL equal to or greater than 3,000,000 may be crushed limestone sand if the limestone sand is from a source not on the Approved Polish Resistant Aggrgate List.</p>
Pneumatic placement	Natural sand suitable for use with a pneumatic sand cement gun.
Mortar	Natural sand
Snow and ice abrasives	Steel furnace slag, air-cooled blast furnace slag, granulated blast furnace slag, natural sand, crushed stone sand, or cinders.

COARSE AGGREGATES

Section **904.03** includes the general requirements for coarse aggregate. This section lists several of the types of materials that can be used as coarse aggregate, and their applications and limitations.

CLASS OF COARSE AGGREGATES REQUIRED FOR VARIOUS TYPES OF CONSTRUCTION	
<i>TYPE OF CONSTRUCTION</i>	<i>REQUIRED QUALITY CLASSIFICATION</i>
Aggregate Base	Class A, B, C, or D
Subbase	Class A or B (No. 8, 43) Class A, B, C, or D (No. 53)
Aggregate Pavements or Shoulders	Class A, B, C, or D
HMA base coarse	Class A, B, C, or D
HMA intermediate course	Class A, B, or C
HMA surface course	Class A or B
Asphalt seal coat	Class A or B
Portland cement concrete pavement	Class AP
Portland cement concrete structural-- exposed	Class A or AP
Portland cement concrete structural-- non-exposed	Class A or B
Cover (choke) aggregates coarse aggregate	Class A or B

Where more than one aggregate classification is allowed, the contractor has a choice, unless specified by provisions within a given contract. The class of aggregate can never be less than the lowest class for the designated use. For example, the highest class of aggregate for HMA surface course, Class A, may be used (with no additional payment to the contractor or producer). Class B aggregate may be used as the minimum requirement.

GRADATION REQUIREMENTS

The gradation or particle-size distribution of an aggregate is usually specified to be within certain limits for various types of construction. There is a great difference between what is considered an acceptable grading for aggregates for the various HMA mixes, for portland cement concrete, or for base layers. The gradation that aggregates are to meet for specific types of construction is contained in the contract plans, special provisions, or standard specifications and is usually designated by the aggregate size.

Sections **904.02** and **904.03** contain tables describing the acceptable particle-size distribution for various sizes of both fine and coarse aggregates. Section **904.04** specifies the sizes for riprap and Section **904.05** lists the acceptable gradations for structure backfill.

FINE AGGREGATES

The table found in Section **904.02** is used to accept six aggregates used for HMA mixes, portland cement concrete, pneumatic placement mortar, mortar sand, and snow and ice abrasives. The table lists the six sizes of fine aggregates--numbers 23, 24, 15, 16, PP and S&I. Number 16 is the finest aggregate, because 100 percent of the fine aggregate must pass the No. 30 sieve. Number 23 is the coarsest of the six sizes. Note that all fine aggregate particles are generally expected to pass the No. 4 sieve.

The aggregates for mortar sand must meet the gradation for size number 15 or an approved gradation from a CAPP source. The fine aggregates for pneumatic placement may meet size number 15, PP, or an approved gradation from a CAPP source.

Snow and ice abrasives must meet the gradation requirements of Section **904.02(f)**.

COARSE AGGREGATES

The table found in Section **904.03** applies to coarse aggregates. The table shows ten sizes of coarse aggregates--numbers 2, 5, 8, 9, 11, 12, 43, 53, 73, and 91. Number 2 is the coarsest size and number 12 is the finest. Numbers 53 and 73 are dense graded aggregates, number 91 is used for aggregates in pre-cast concrete, and number 43 is used for an aggregate drainage layer.. Note that the majority of the aggregate is retained on the No. 4 sieve and larger.

B BORROW AND STRUCTURE BACKFILL

B Borrow and structure backfill requirements are listed in Section **211**.

Materials for B Borrow are required to contain no more than 10 percent passing the No. 200 sieve and shall be otherwise suitably graded as noted in Section **211.02**. The use of an essentially one-size material will not be permitted unless approved.

Structure backfill gradations are defined in Section **904.05**. The percent of material required to pass varies by aggregate size. For example, for the 2 in. aggregate, at least 90 percent should pass the 2 in. sieve. For the 1 in. aggregate, at least 85 percent should pass the 1 in. sieve, and for the No. 30 aggregate, at least 70 percent should pass the No. 30 sieve.

RIPRAP

Aggregate used for this purpose is found in Section **904.04**. These materials are typically large and are used as a protective coating as specified. Revetment, Class 1, Class 2, and Uniform Riprap shall meet the requirements of Section **904.04(e)**. The other ripraps listed have general size limitations.

AGGREGATE BASE

Section **301** includes the requirements for dense graded compacted aggregate material. No. 53 aggregate is used for this purpose.

SUBBASE

Section **302** includes the requirements for subbase placed on a prepared subgrade for portland cement concrete pavement. Subbase consists of either a No. 8 or No. 43 aggregate as the drainage layer over a No. 53 aggregate as the separation layer. Where a dense graded subbase is required, only No. 53 aggregate is used.

AGGREGATE PAVEMENTS OR SHOULDERS

Section **303** includes the requirements for aggregates when used for pavements or shoulders. No. 53 and No. 73 aggregate is used for this purpose except that No. 73 aggregate is only used for surface courses.

SUMMARY OF GRADATION REQUIREMENTS

The gradation requirements for fine and coarse aggregates as specified in various sections of the Standard Specifications for significantly different types of construction are summarized below. This listing is not all inclusive, but covers the major uses of aggregates. A review of the Standard Specifications is always necessary.

TYPE OF CONSTRUCTION REQUIREMENTS	GRADATION
Aggregate base * Coarse aggregate	No. 53
Subbase * Coarse aggregate	No. 8, 43, 53
Aggregate Pavements or Shoulders * Coarse aggregate	No. 53, 73
Asphalt Seal Coat * Fine Aggregate * Coarse Aggregate	Nos. 23 or 24 Nos. 8, 9, 11, 12
Portland cement concrete pavement/structural * Fine aggregate * Coarse aggregate	No. 23 No. 8